INFLUENCE OF THE INTENSITY OF IRRADIATION ON THE NEW LIGHT-EFFECT IN CHLORINE UNDER ELECTRICAL DISCHARGE

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(Plate I)

ABSTRACT. General conditions for the production of a new light-effect, *viz.*, a photo-diminution of the conductivity in chlorine subjected to electrical discharge, are indicated. The effect increases by increasing the frequency of irradiation, the violet being most active, which happens to be the region of absorption by chlorine. In agreement with Joshi's views, who regards this phenomenon as distinct from a negative photo-electric effect, the influence of the light-intensity on the effect is not linear.

INTRODUCTION

Occurrence of a photo-diminution of the conductivity due to electrical discharge in chlorine and other gases has been established by Joshi (1943) and co-workers (1939, 1941, 1943). The present communication reports results for the dependence of this new electro-optical phenomenon upon the applied potential, the nature, and the intensity of irradiation.

EXPERIMENTAL ARRANGEMENT

The experimental arrangement and electrical circuit are shown in Fig. 1. Single-phase alternating current of 50 cycles frequency was obtained from a 1 k.W. rotary converter worked off the D.C. mains. The potential was stepped up by means of a high tension transformer (2 KVA, 150/40,000 volts, 50-500Ω). With the help of a potentiometric arrangement it was possible to regulate the primary potential of the transformer within 1 per cent. The primary current and voltage were observed by an ammeter A and a volt-meter V (Fig. 1) respectively. V, the secondary potential was obtained from a knowledge of the transformer ratio.

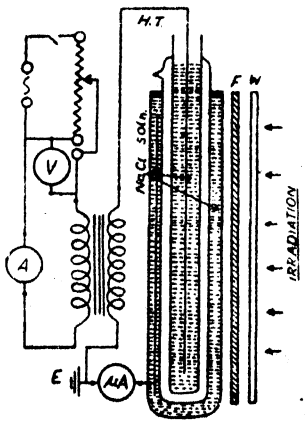

FIG. 1

Chlorine was prepared electrolytically from concentrated hydrochloric acid by passing a current of 0.25 amp. It was freed from the acid by bubbling through water, and dried by leading through concentrated sulphuric acid and finally over freshly prepared phosphorus pentoxide. Further purification was effected by freezing the gas in a trap cooled by liquid air and pumping out with a Töpler any uncondensed gases. This process of drying and purification was repeated several times until the spectrum of a sample of the gas viewed through a direct vision spectroscope was found to be free from impurities.

The discharge was produced in the annular space of a Siemens' type glass ozonizer, of which two (A', A) were used; they were filled with chlorine at pressures of 5.6 and 11.0 cm. Hg. respectively. The discharge current i was measured by a Cambridge A.C. microammeter, shunted with a suitable non-inductive resistance, introduced in the secondary circuit. A 200 watt incandescent bulb run at 180 volts was the light source. The water-cell W (Fig. 1)

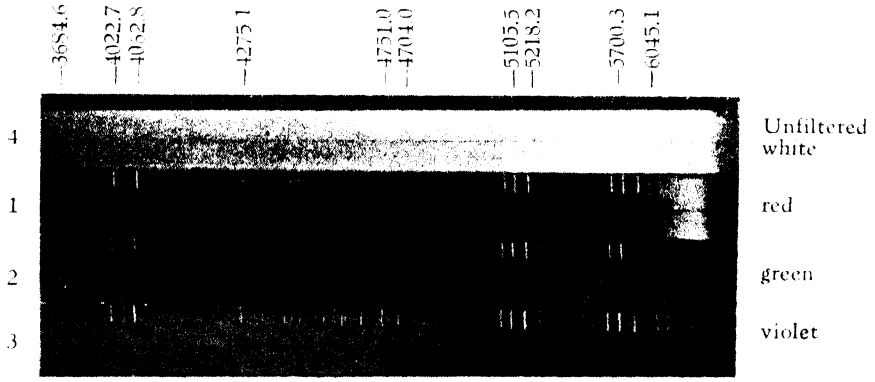
3884.6
4022.7
4062.8
4275.1
4751.0
4704.0
5105.5
5218.2
5700.3
6045.1
4
1
2
3
Unfiltered white
red
green
violet

FIG. 4

served to minimise the heat radiations. The effective frequency of irradiation was varied by employing coloured glass strips F ; the size of the ozonizer did not permit the use of Wratten or similar light filters.

RESULTS AND DISCUSSION

Using ozonizer A[1], data for the characteristic V-i curves were obtained with V, varied within the range 7.0 to 13.0 kV. (Fig. 2). These curves show the essence of *the new phenomenon, namely that the discharge current produced due to various applied potentials diminishes as a result of irradiation.* Table I shows that for a given wave-band, Δi the light-effect increases with V. At constant V, Δi varies in the order : white > violet violet (double) > red ; the corresponding intensity of incident energy, observed with a Kipps 37 thermopile, expressed in relative units was 34.1 (white), 16.5 (violet), 8.7 (violet double) and 22.2 (red). This shows that *ceteries paribus*, frequency is the main determining factor in the production of this phenomenon. The influence of the light intensity at constant frequency is illustrated by the fact that for the whole series, Δi for double filtered violet is less than that when one violet filter is used (Fig 2, curves 3 & 4). It is instructive to recall at this stage a previous observation, *viz.*, that the variation of Δi with I, the intensity is markedly influenced by the initial value of I ; and that at higher intensity Δi tends to a limiting value probably as a consequence of saturation. This factor may be responsible for the fact that $\Sigma\Delta i$ expressed as the sum of Δi observed separately under each of the various bands comprising the white light is greater than Δi for the white. It is to be anticipated that this effect will decrease at lower intensity (*vide infra*).

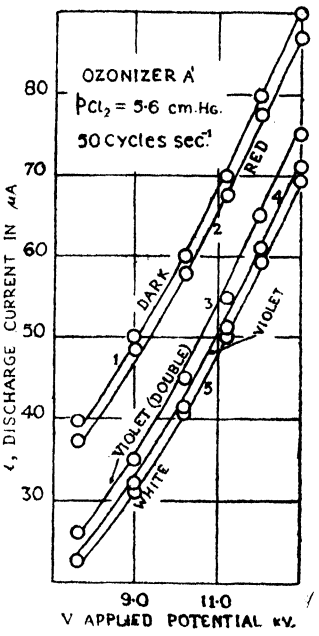

FIG. 2

TABLE I

Variation with V the Applied Potential and different Irradiations, of i the Discharge Current in Cl_2

(Ozonizer A', PCl_2 = 5.6 cm. Hg.)

Primary volts (r.m.s.)	V, Secondary kilovolts (r.m.s.)	1	Red 2			Violet (double) 3			Violet 4			White 5			2+4	
		i	i	Δi	$\%\Delta i$	i	Δi	$\%\Delta i$	i	Δi	$\%\Delta i$	i	Δi	$\%\Delta i$	$\Sigma\Delta i$	$\Sigma\%\Delta i$
28.5	7.6	40.0	38.0	2.0	5.0	26.0	14.0	35.0	22.5	17.5	43.9	22.5	17.5	43.9	19.5	48.9
33.5	8.9	50.0	48 5	1.5	3.0	35.0	15.0	30.0	32.0	18.0	36.0	31.0	19.0	38.0	19.5	39.0
38.0	10.2	60.0	58.0	2.0	3.3	45.0	15.0	25.0	41.5	18 5	30.8	40.5	39.5	32.5	20.5	34.1
42.0	11.2	70.0	67.5	2.5	3.6	55.0	15.0	21 4	51.0	19.0	27.1	50.0	20.0	28.5	21.5	30.7
45.0	12.0	80.0	77.5	2.5	3.1	65.0	15.0	18.7	51.0	19.0	23.7	59.5	20.5	25.2	21.5	26.8
48.5	12.9	90.0	87.0	3.0	3.3	75.0	15.0	16.7	71.0	19.0	21.1	69.0	21.0	23.3	22.0	24.4

The above findings have been investigated in some detail on another system (ozonizer A), particularly in regard to the influence of I the intensity. In this series of experiments V the applied potential (9.3 kV. r.m.s.) was kept constant; i the corresponding discharge current in dark was 55 micro-amps. Δi, the diminution in i produced due to each of the various frequency-bands is shown in Table II. The relative total intensities of these bands were measured with a Kipps 37 thermopile and also with a RCA 918, caesium coated photo-cell, applying 50 volts as the accelerating potential (*cf.* Table II): the relative intensity is also indicated by the corresponding spectra (Fig. 4) taken with a Fuess spectrograph on Kodak P 1200 super-panchromatic plates with a 10 second exposure. I was varied by varying the ozonizer-distance from the light source over a range of 30 to 100 cms. Whilst Δi, due to the (unfiltered) white and violet was appreciable at even longer distances, that due to red and green had practically reached the limit of the sensitivity of the available microammeter at even less than 100 cms. Assuming the inverse square law to a first approximation the Δi-distance^{-2}curves in Fig. 3 show the variation with intensity of Δi in different spectral regions, at a constant exciting potential.

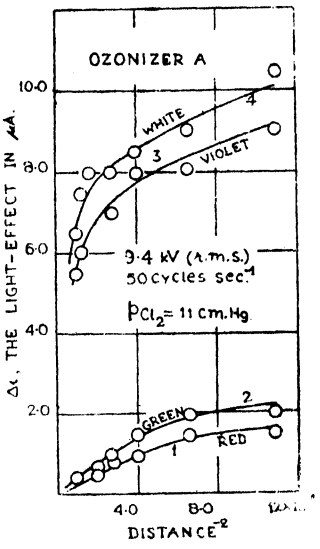

FIG. 3

TABLE II

Variation with I the Intensity of Irradiation in different Spectral Regions of Δi the Light-effect in Cl_2 at constant Potential

(Ozonizer A'; PCl_2 = 11 cm. Hg.; 9.4 kV)

Distance cms.	Red 1	Δi Light-effect in μA: Green 2	Violet 3	White 4	$\Sigma\Delta i$ 1+2+3
30	1.5	2.0	9.0	10.5	12.5
40	1.5	2.0	8.0	9.0	11.5
50	1.0	1.5	8.0	8.5	10.5
60	1.0	1.0	7.0	8.0	9.0
70	0.5	0.5	7.0	8.0	8.0
80	...	0.5	6.5	8.0	7.0
90	...	...	6.0	7.5	6.0
100	...	...	5.5	6.5	5.5
I, total intensity (relative)	19.0 460	0.1 0.3-0.4	12.0 440	45.6 1050	with thermopile with photocell

As observed earlier by Joshi and others these results show that this light-effect under white and violet is much more pronounced than that due to green and red which may be associated with the fact that both the former include appreciably the absorption spectrum of chlorine. It

is known that the spectral sensitivities of a photo-electric cell and a thermo-pile are not the same. The results of both these methods (Table II) and the spectra in Fig. 4 show, however, the same order of variation in respect of the intensity of the light-band, *viz.*, green < violet < red < white. A comparison of Δi due to these light-bands shows that intensity is not the primary determinant of the magnitude of this phenomenon. The greater Δi under green (Fig. 3, curve 2) despite its low intensity compared with red (curve 1) shows that the frequency is the more predominant factor. It is also instructive to observe that whilst the over-all intensity in the region beginning from about 4704 A towards the ultra-violet is much greater in the unfiltered white (Plate I) (spectrogram 4) than the violet (spectrogram 3), and that the former contains a more intense short-wave region, *viz.*, 4032 to 3684 A than the latter, the magnitude of the light-effect is not correspondingly greater under white than violet (Table II). This may be due to saturation ; it is also suggested by a comparison of the sum, Δi red + Δi green + Δi violet = $\Sigma\Delta i$ (say), with the corresponding Δi under white (Table II). It is seen that $\Sigma\Delta i$ the additive effect exceeds the corresponding Δi due to white, and that the excess is the more pronounced, the greater the intensity of irradiation. At small I, when the saturation effect should be low, $\Sigma\Delta i$ is less than that for white, as is to be expected. It is also seen from Fig. 3 that comparatively, the increase of Δi with I is more steep in white > violet > green > red. That Δi tends generally to fall off subsequently, *i.e.*, when I is large, is an additional indication of saturation.

Fig. 3 shows that Δi is not a linear function of the corresponding intensity of irradiation, a result which has been emphasized by Joshi as differentiating this phenomenon from the classical photo-electrical effect.

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REFERENCES

Joshi (1943), *Proc. Indian Sci. Cong.* (Presidential Address, Chemistry Sec.).

Joshi and others (1939), *Curr. Sci.*, **8**, 548.

" " (1943), " " **9**, 536.

" " " " " **12**, 306.

" " (1941), *Nature*, **147**, 806.

" " (1943), " **151**, 561.